Francesco Memorial

- Beam echo's
- ZBASE: an impedance data base
- electron cloud studies

➔ summary of the activities during my fellowship time at CERN

➔ it was agreed that I would work at CERN on collective effects

➔ I joined Francesco's section on collective effects in 1995

➔ all the reported work was done by strong collaborations between many people!!!

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- Beam echo's

Francesco's first assignment was to give me a paper by Pat Colestock, Ostiguy and Spenzouris on Beam Echo measurements in the Tevatron and the potential application of measuring small diffusion processes in an accelerator

-echo phenomena have been studied since the 50's

➔ spin echo's: E. Hahn 1950

➔ plasma wave echo's: O'Neil 1968

➔ echo effects in hadron colliders: Stupakov 1992

➔ beam echo studies in the CERN SPS in 1995

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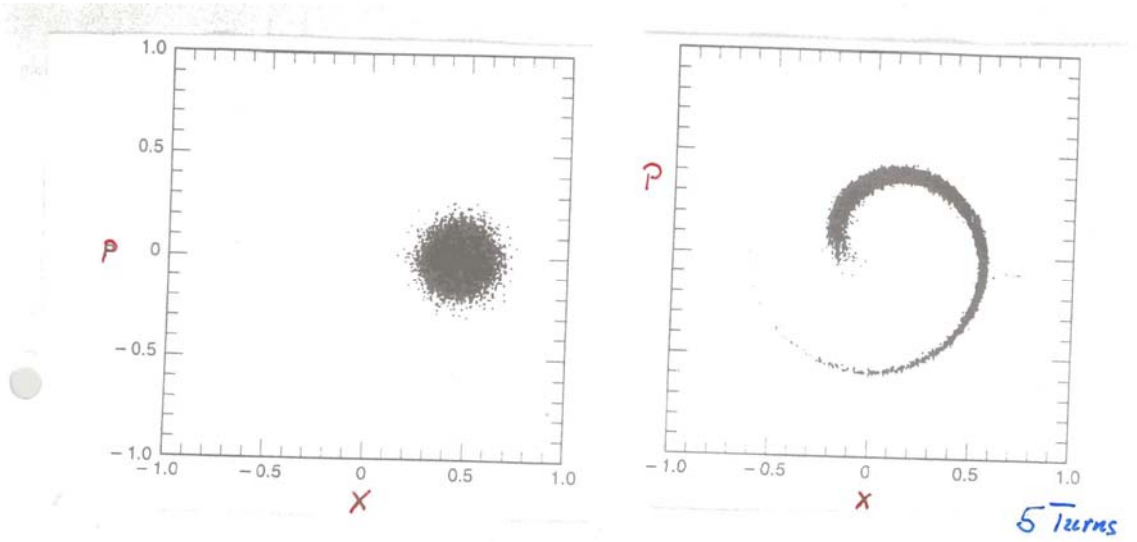
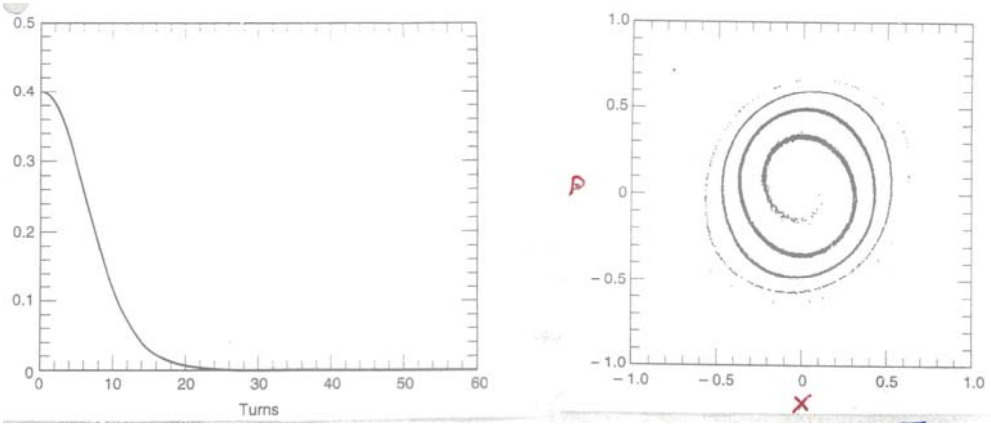
- Illustration of transverse beam echo's (Stupakov & Kauffmann)

transverse offset:



filamentation and quadrupole kick after 21 turns:



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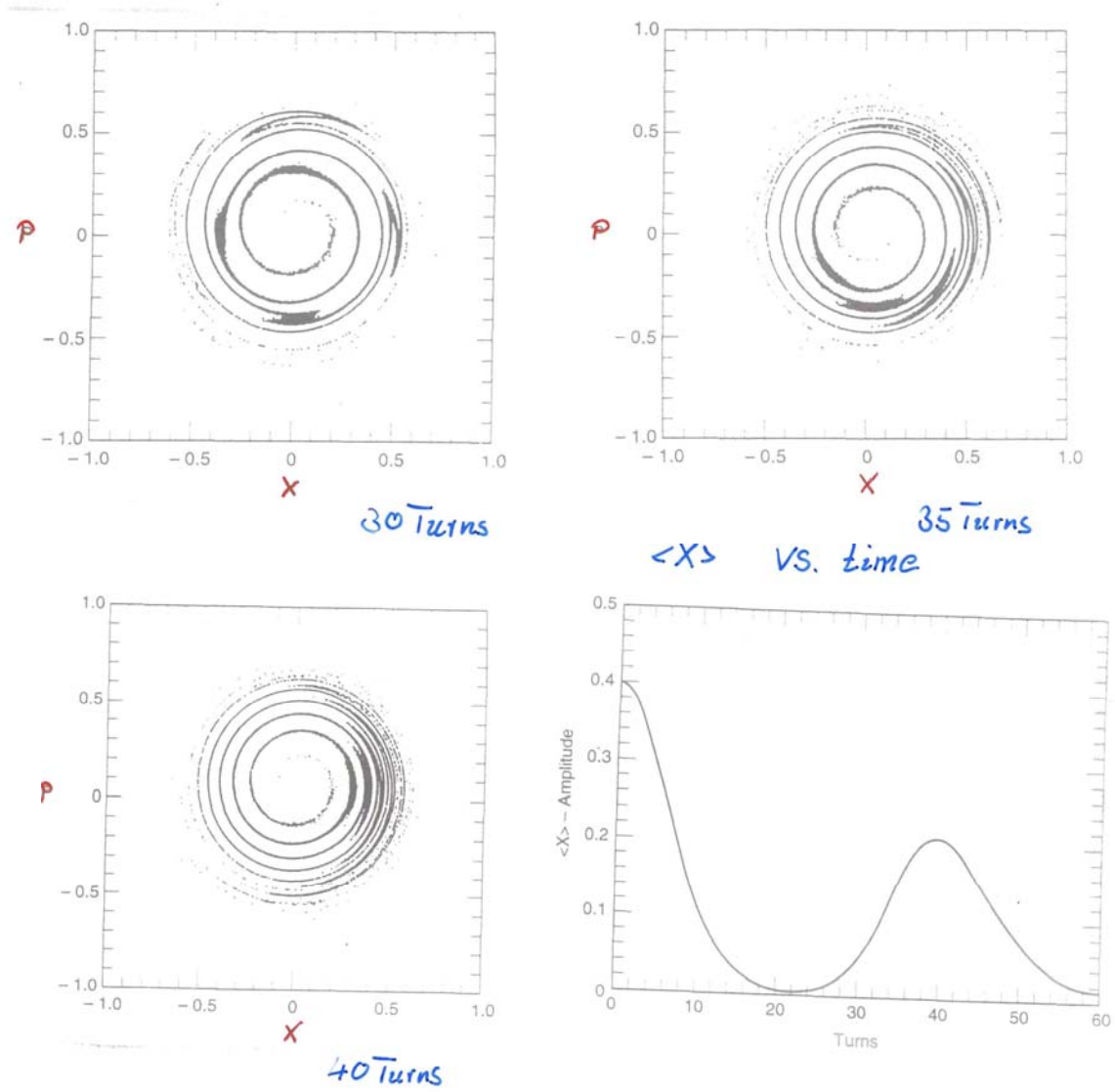
- illustration of transverse beam echo's (Stupakov & Kauffmann)

filamentation after 35 turns:

response at BPM:



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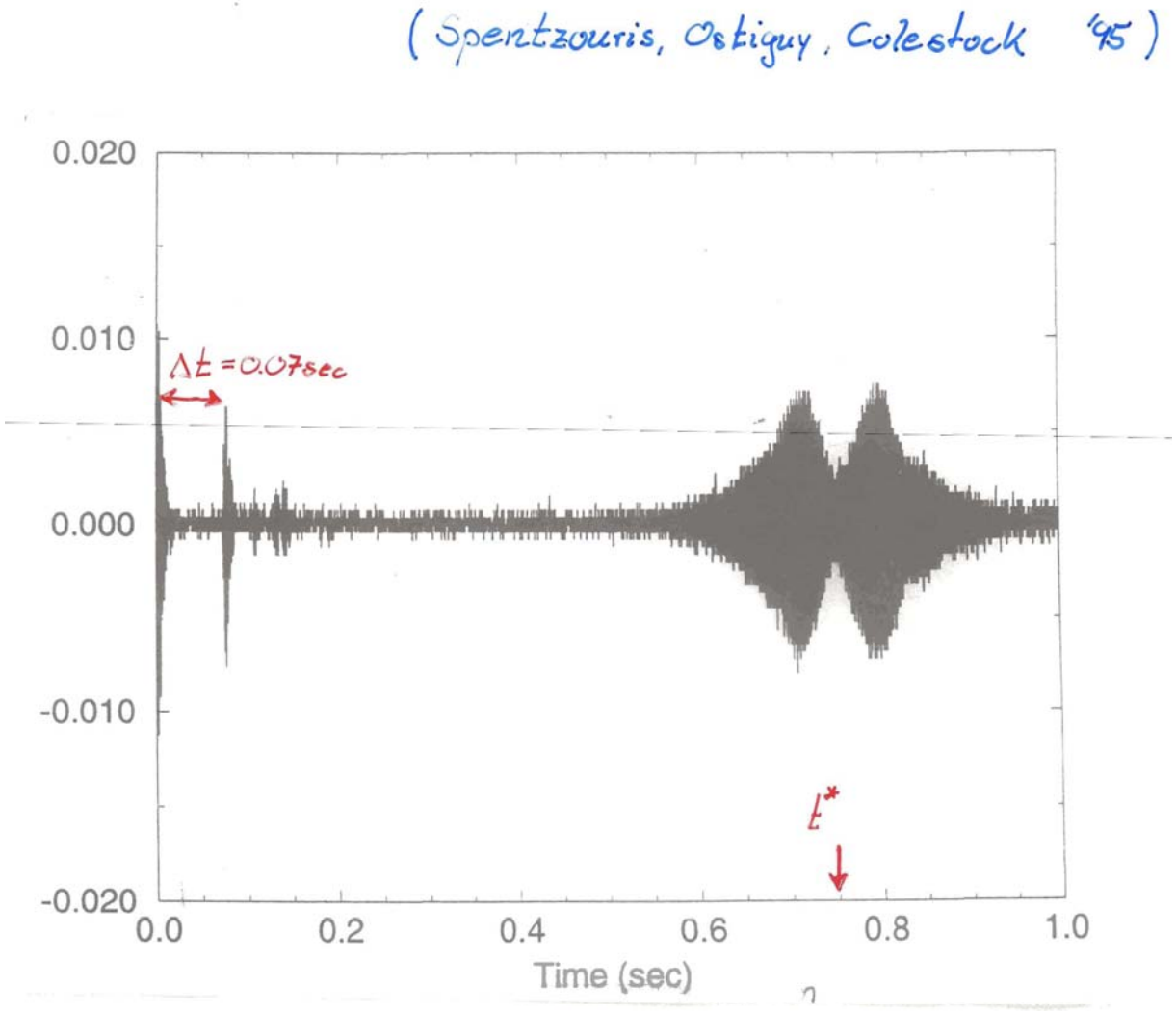
- longitudinal echo response in the beam current:



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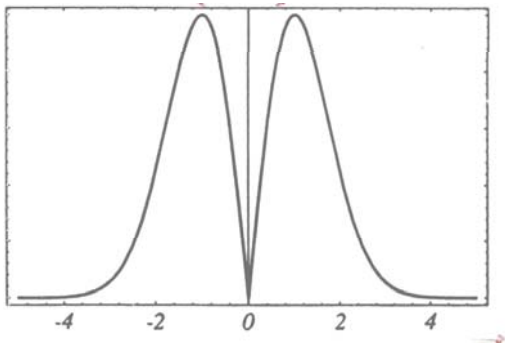
longitudinal echo response in the beam current:

$$I(t) = A_{form}(\rho) \cdot A_{env}(t_1, t_2) \cdot A_{diffusion}(D, t)$$



➔ the echo response can be used for measuring small diffusion coefficients in relatively short time scales

the work at CERN clarified the correct interpretation of the diffusion term and provided the prerequisite for using this technique in a storage ring

strong collaboration within CERN between ABP, RF and OP

➔ strong international collaborations with measurements in:
AGS, RHIC, HERA, Tevatron and SPS

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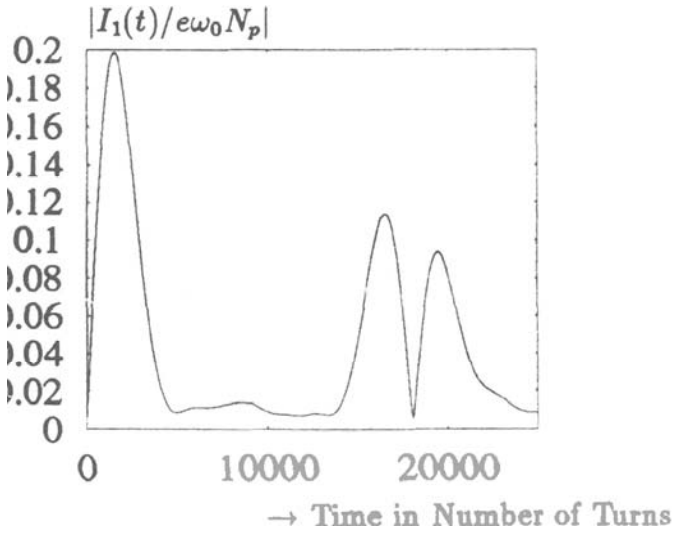
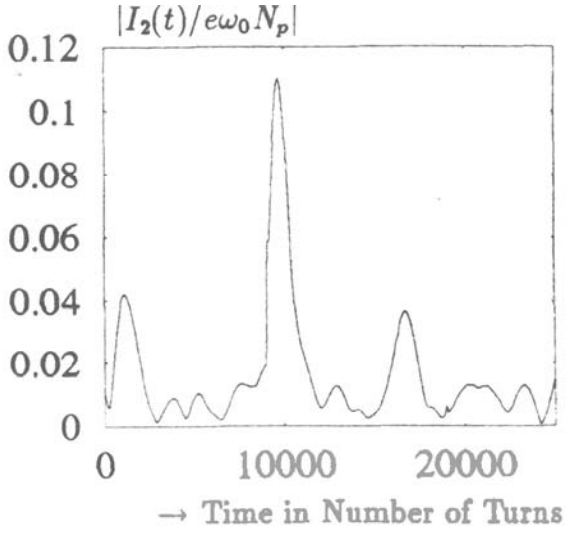
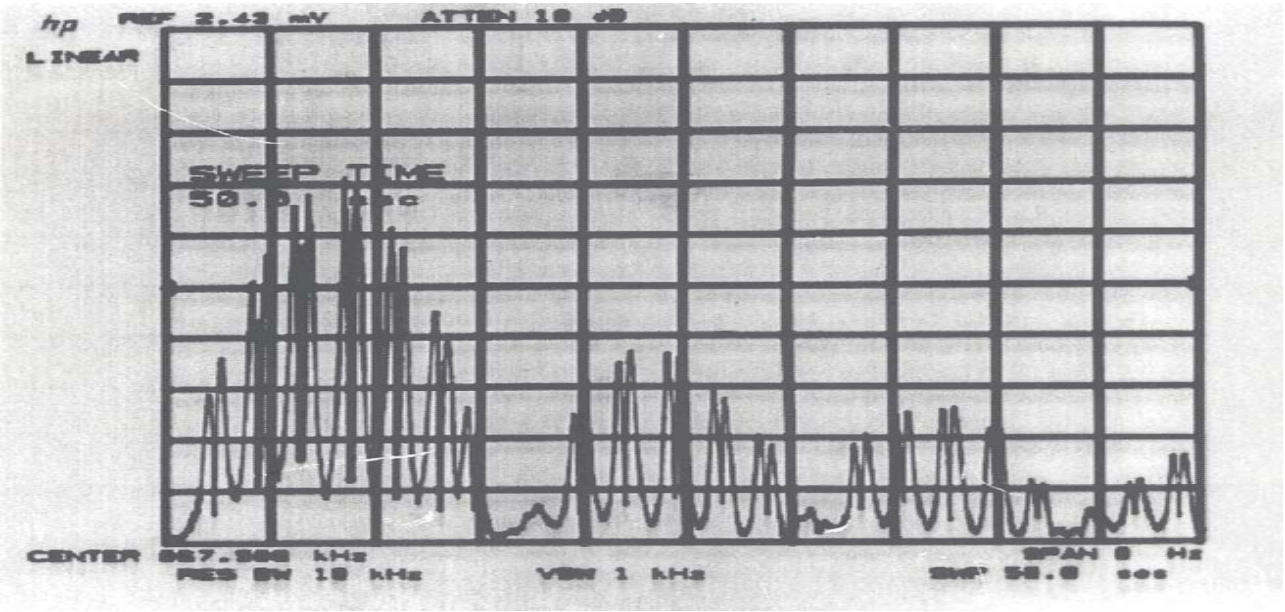
measurements in the SPS:







echo response up to 120 sec after kicks!

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ZBASE:

when I joined the collective effects team Francesco asked me to evaluate the LEP impedance during as the Cu cavities were replaced by SC cavities and to estimate the TMCI threshold as a function of installation progress

➔ this implied collecting the impedance data for different items from various groups (e.g. RF, VAC etc.)

➔ and to re-evaluate the wake fields and loss factors for shorter bunch length (requiring access to different computer tools: MAFIA, ABCI etc)

The data was not always easy to get (geometry and wake potentials) and was generally not in the same format

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ZBASE:

This triggered the idea of building a data base that ensures:

➔ common data format (e.g. measured data and data from simulation or theoretical formulas)

➔ link to the programs that were used for calculating the impedance or wake potentials

➔ provides tools for summing impedance and wake potential data for different items and converting from one to the other

➔ includes information of the relevant beam and optics data

➔ provides tools for evaluation some of the key threshold values (e.g. TMCI and multi bunch instability thresholds)

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ZBASE:

For this to be a success, the work had to:

➔ be done in the framework of a broad collaboration at CERN (e.g. RF, VAC) and in close collaboration with our external colleagues from other laboratories (e.g. Scott Berg and M. Djatchkov)

➔ the data base had to be accessible from anywhere

➔ implementation on ‘afs’

➔ the data base had to be accessible from any platform

➔ choice of an interpreted language (Tcltk)

➔ be expandable to other machines than LEP ➔ include LHC from the start

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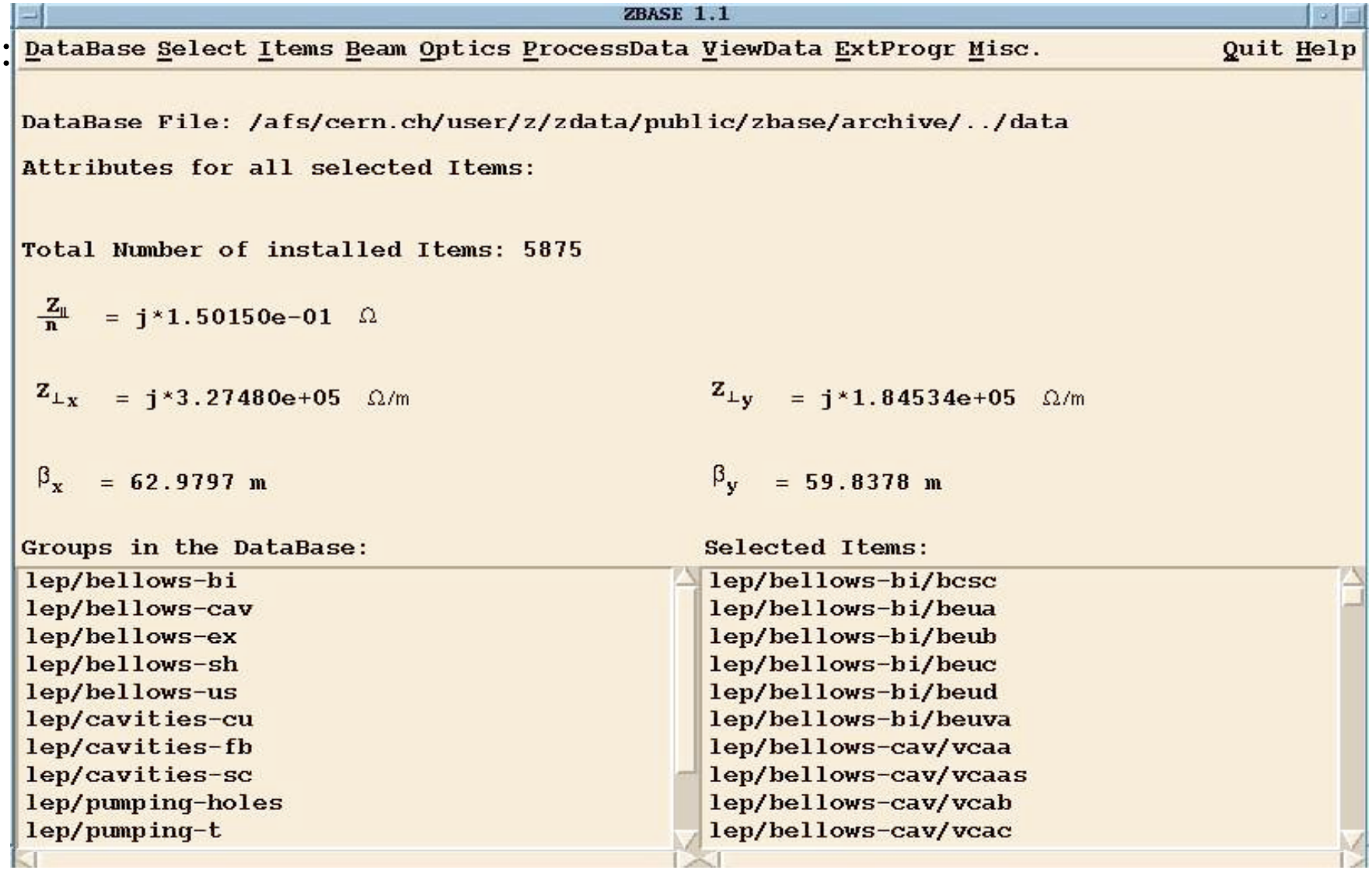
ZBASE interface:



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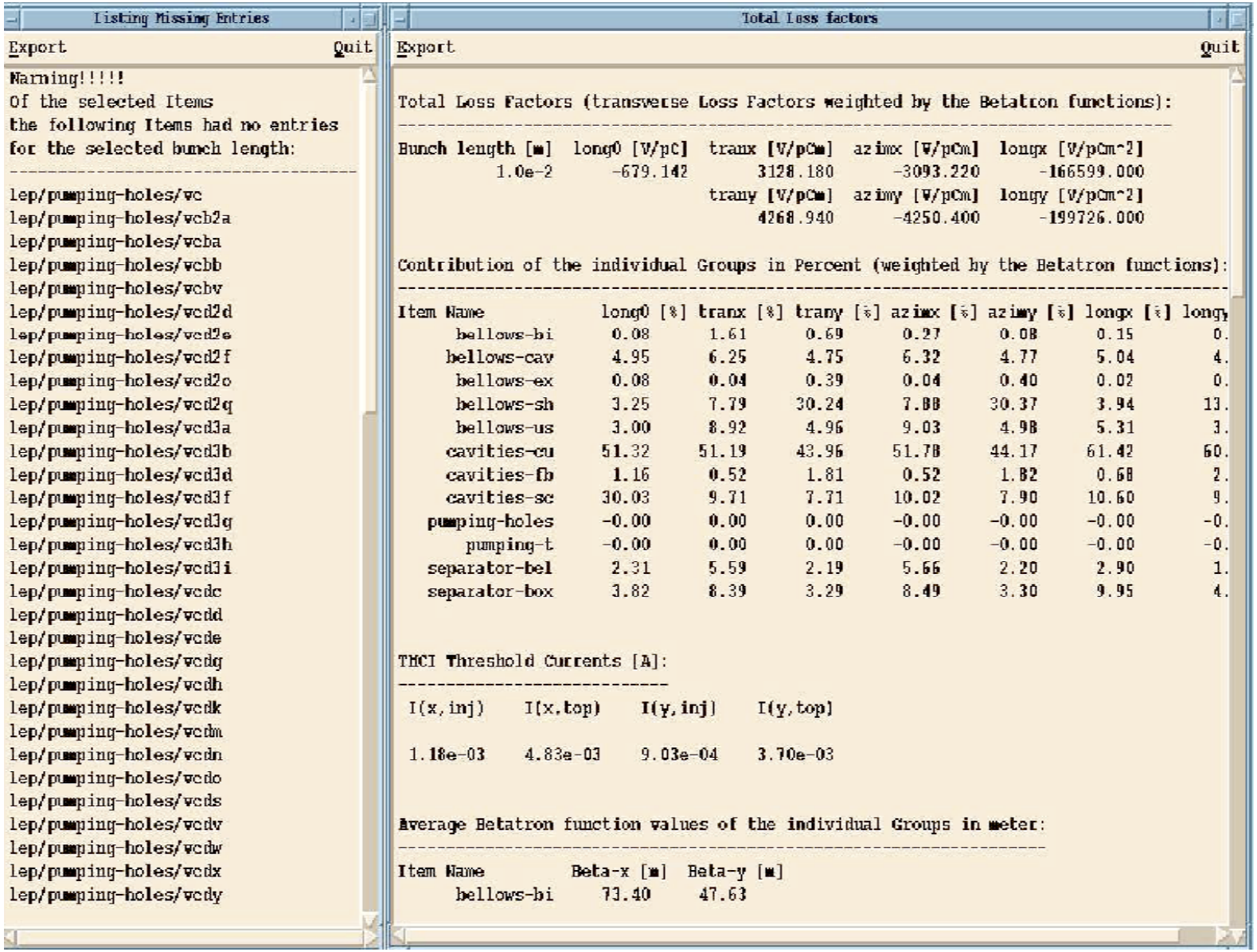
ZBASE: loss factor



Listing Missing Entries

Export Quit

```
Warning!!!!!
Of the selected Items
the following Items had no entries
for the selected bunch length:
-----------------------------------
lep/pumping-holes/vc
lep/pumping-holes/vcb2a
lep/pumping-holes/vcba
lep/pumping-holes/vcbb
lep/pumping-holes/vcbv
lep/pumping-holes/vcd2d
lep/pumping-holes/vcd2e
lep/pumping-holes/vcd2f
lep/pumping-holes/vcd2o
lep/pumping-holes/vcd2q
lep/pumping-holes/vcd3a
lep/pumping-holes/vcd3b
lep/pumping-holes/vcd3d
lep/pumping-holes/vcd3f
lep/pumping-holes/vcd3g
lep/pumping-holes/vcd3h
lep/pumping-holes/vcd3i
lep/pumping-holes/vcdc
lep/pumping-holes/vcdd
lep/pumping-holes/vcde
lep/pumping-holes/vcdg
lep/pumping-holes/vcdh
lep/pumping-holes/vcdk
lep/pumping-holes/vcdm
lep/pumping-holes/vcdn
lep/pumping-holes/vcdo
lep/pumping-holes/vcds
lep/pumping-holes/vcdv
lep/pumping-holes/vcdw
lep/pumping-holes/vcdx
lep/pumping-holes/vcdy
```

Total Loss factors

Export Quit

Total Loss Factors (transverse Loss Factors weighted by the Betatron functions):

Bunch length [m]	long0 [V/pC]	tranx [V/pCm]	azimx [V/pCm]	longx [V/pCm^2]
1.0e-2	-679.142	3128.180	-3093.220	-166599.000
		trany [V/pCm]	azimy [V/pCm]	longy [V/pCm^2]
		4268.940	-4250.400	-199726.000

Contribution of the individual Groups in Percent (weighted by the Betatron functions):

Item Name	long0 [%]	tranx [%]	trany [%]	azimx [%]	azimy [%]	longx [%]	longy
bellows-bi	0.08	1.61	0.69	0.27	0.08	0.15	0.
bellows-cav	4.95	6.25	4.75	6.32	4.77	5.04	4.
bellows-ex	0.08	0.04	0.39	0.04	0.40	0.02	0.
bellows-sh	3.25	7.79	30.24	7.88	30.37	3.94	13.
bellows-us	3.00	8.92	4.96	9.03	4.98	5.31	3.
cavities-cu	51.32	51.19	43.96	51.78	44.17	61.42	60.
cavities-fb	1.16	0.52	1.81	0.52	1.82	0.68	2.
cavities-sc	30.03	9.71	7.71	10.02	7.90	10.60	9.
pumping-holes	-0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.
pumping-t	-0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.
separator-bel	2.31	5.59	2.19	5.66	2.20	2.90	1.
separator-box	3.82	8.39	3.29	8.49	3.30	9.95	4.

TMCI Threshold Currents [A]:

I(x,inj)	I(x,top)	I(y,inj)	I(y,top)
1.18e-03	4.83e-03	9.03e-04	3.70e-03

Average Betatron function values of the individual Groups in meter:

Item Name	Beta-x [m]	Beta-y [m]
bellows-bi	73.40	47.63

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ZBASE:

not an easy task!

➔ we are by now at the 3rd generation of ZBASE (and still not finished!)

➔ strong collaboration at CERN (e.g. ABP and RF) and beyond

➔ however, the fact that the data base is still being developed shows that there is a need for such a data base

➔ shows that Francesco had the right vision when he asked me to start this work!

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- electron cloud studies:

this work started in 1995 when Frank Zimmermann visited CERN

➔ Frank's work indicated a potential limitation for the beam intensities in the LHC due to the limited cooling capacity of the LHC beam screens

➔ the problem required a crash program at CERN that studies the implications of this effect for the LHC operation and looks at potential remedies for the LHC before all hardware designs were frozen

➔ strong collaboration between different groups at CERN (e.g. AB, AT and TS) and other laboratories world wide (e.g. LBNL, SLAC and BNL)

➔ further studies showed that electron cloud effect is not only a problem for the LHC (e.g. SPS)!

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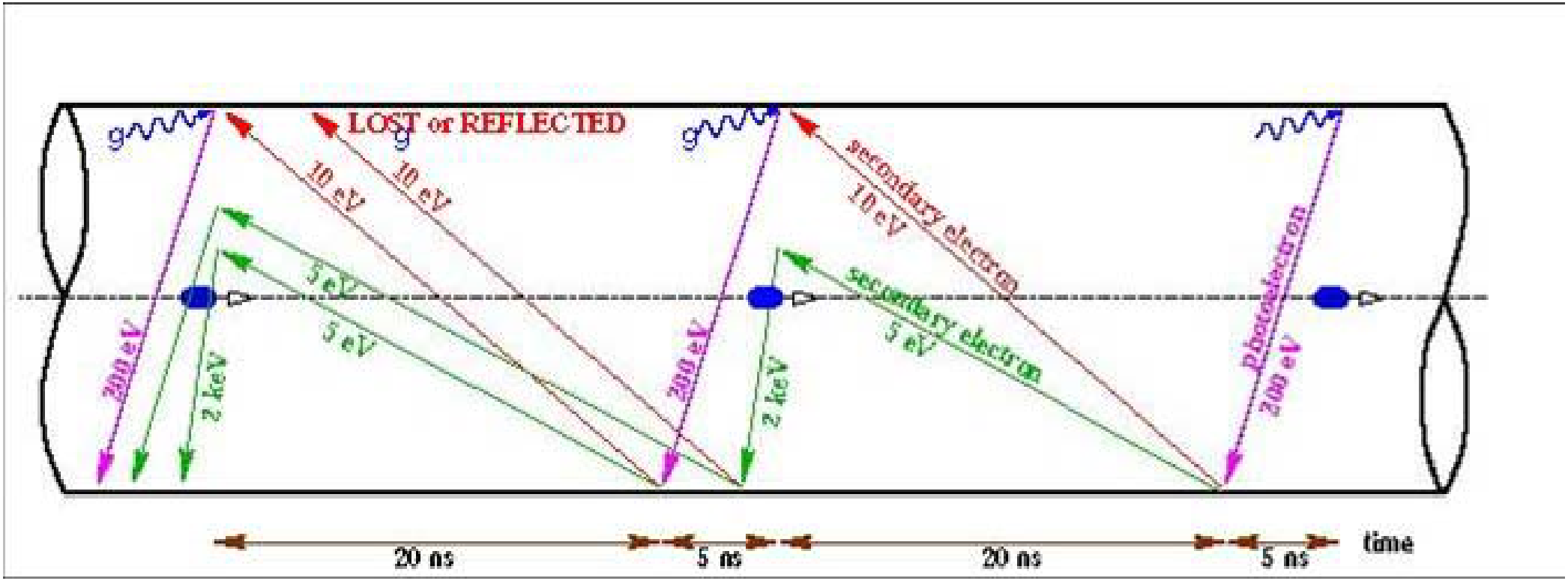
electron cloud effect illustration:

illustration by Francesco



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- electron cloud studies:

  - ➔ first studies aimed at a consolidation of Franks code and an estimate of the parameter dependence of the expected heat-load

  - ➔ further studies looked at surface properties (secondary emission yield, energy spectrum of emitted electrons and surface conditioning due to synchrotron light and electron bombardment) and the impact of the low temperatures in the LHC in laboratory setups

➔ COLDEX in EPA SLF 92

➔ coaxial measurement setup

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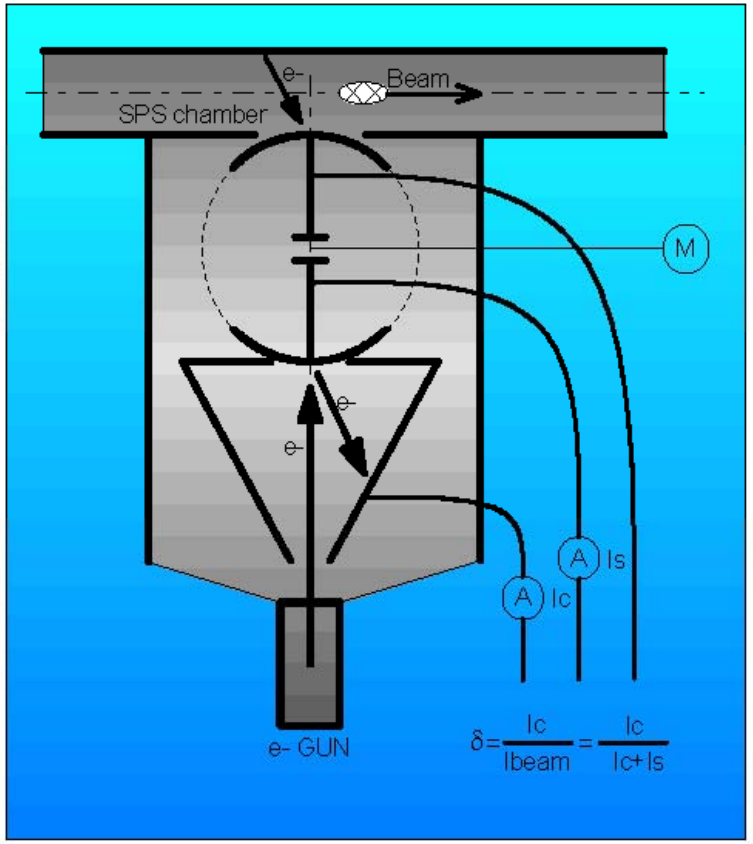
- electron cloud studies:

➔later studies used the SPS as a test bed and looked at measurements with beam

secondary emission yield measurements



(Courtesy of B. Henrist, N. Hilleret)

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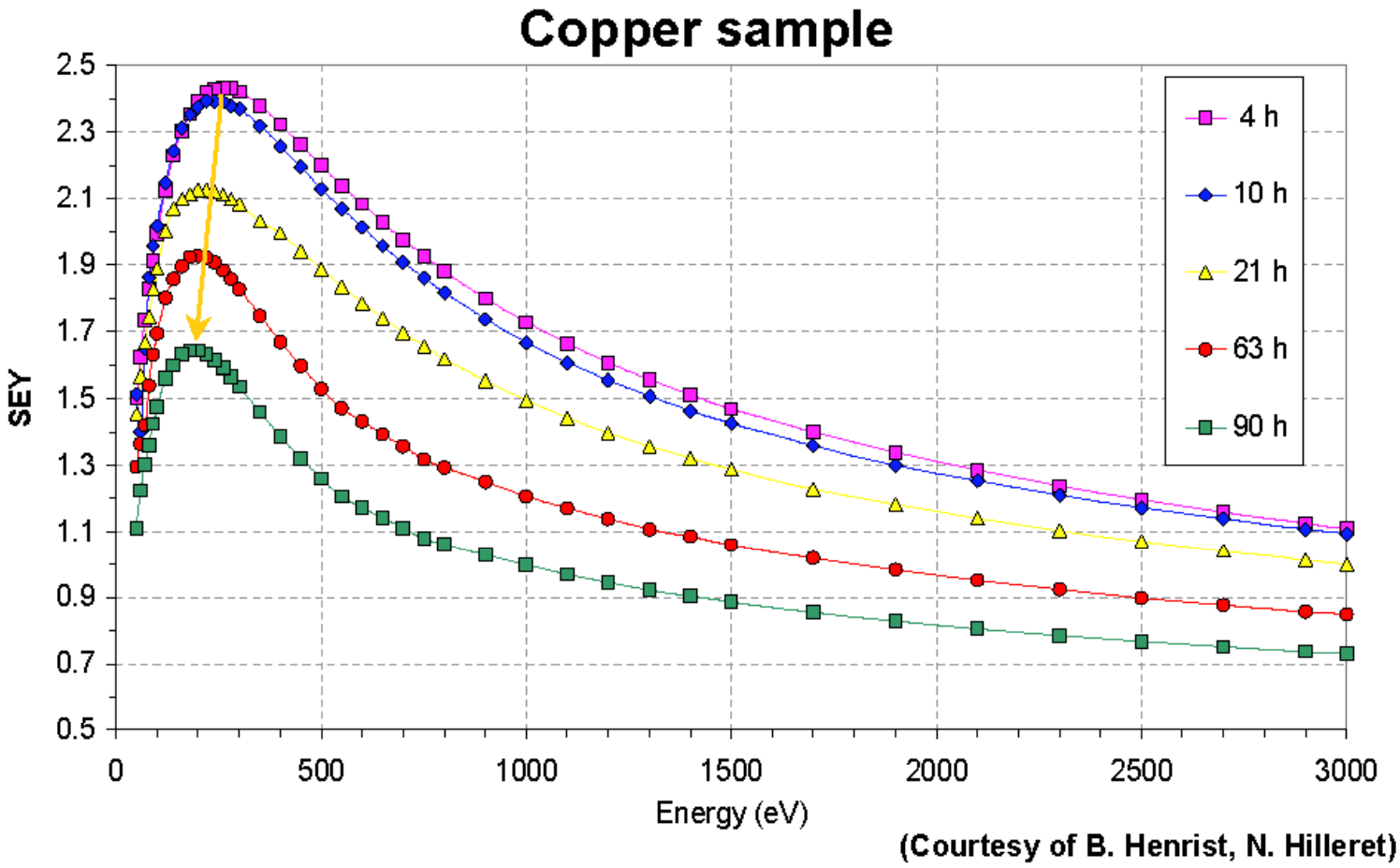
SPS measurements:

evolution of secondary emission yield as function of beam exposure



(Courtesy of B. Henrist, N. Hilleret)

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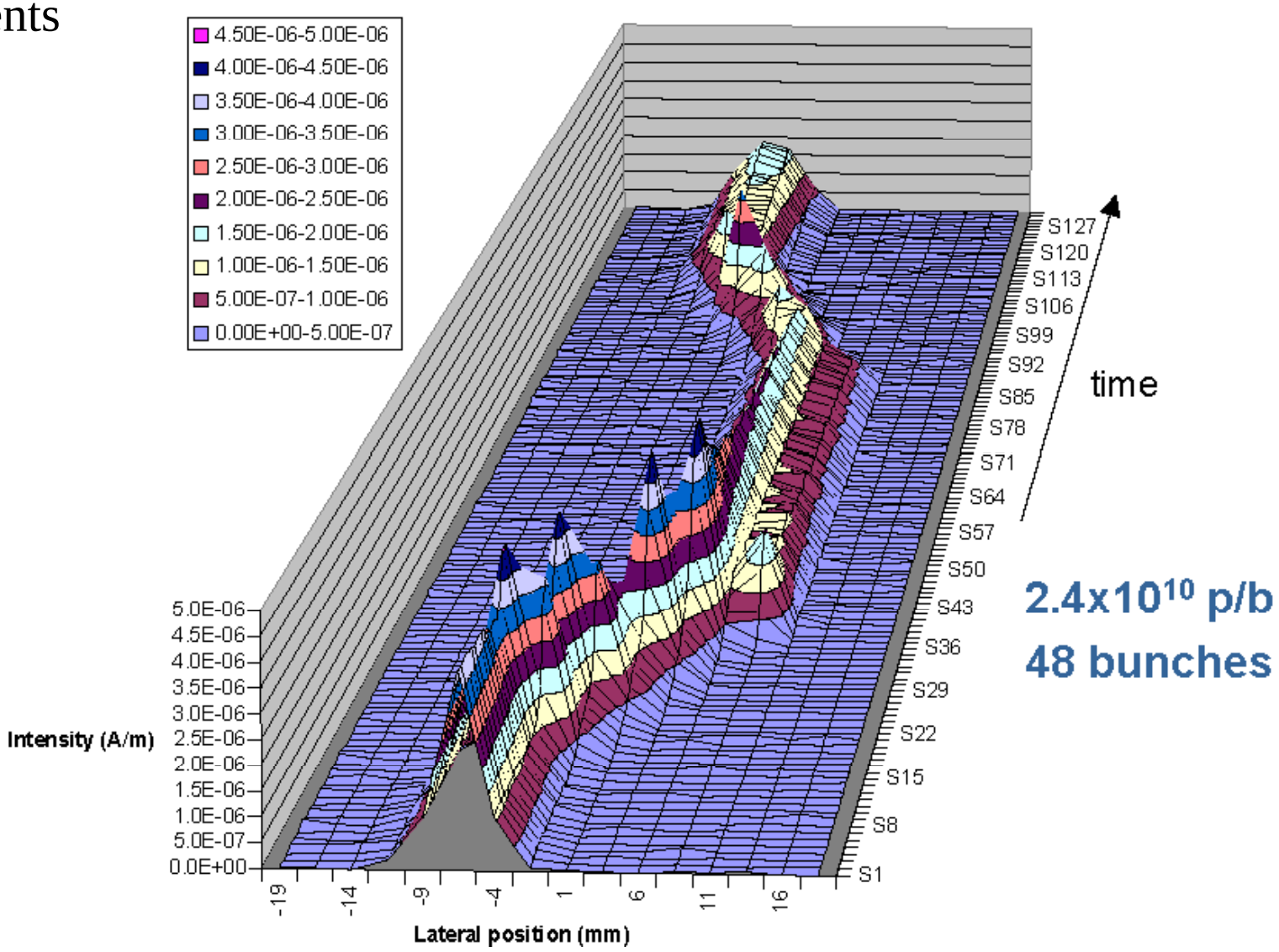
SPS measurements

multipacting signal along the bunch train



2.4×10^{10} p/b

48 bunches

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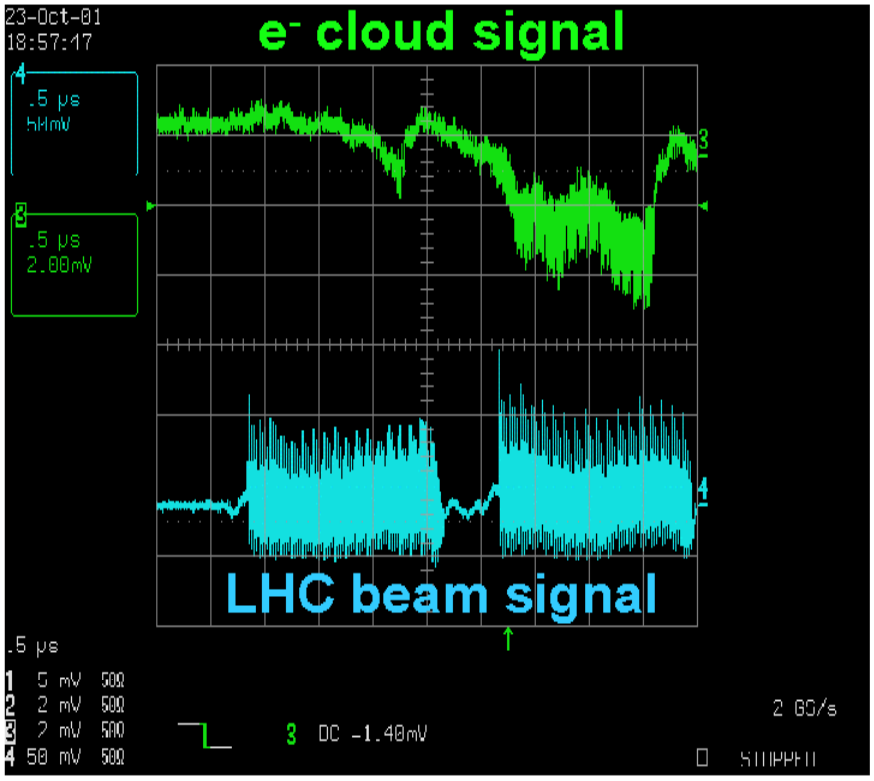
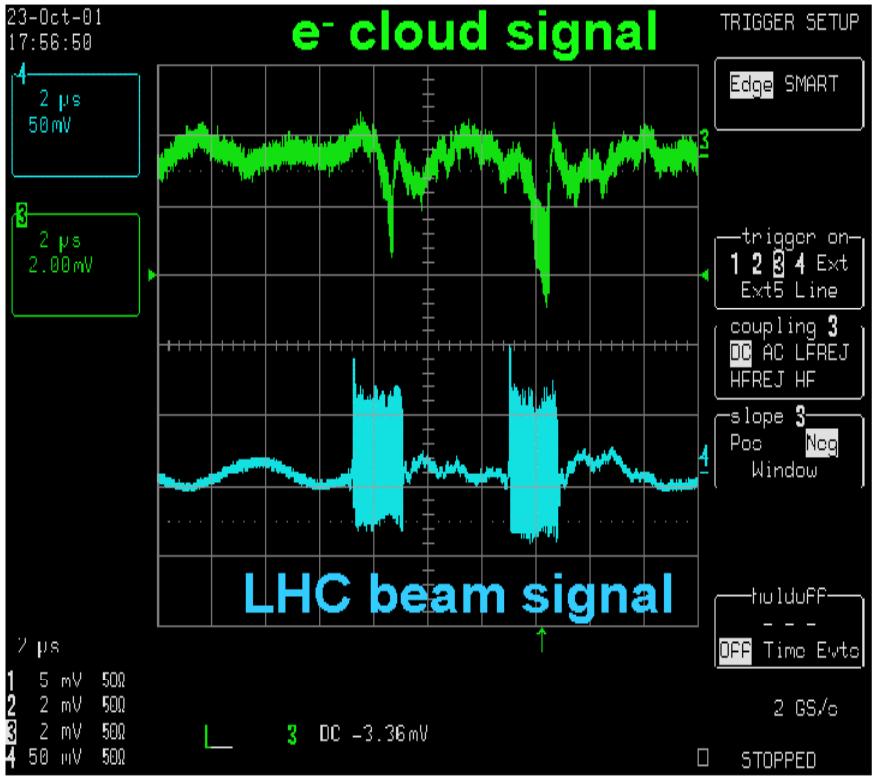
- SPS measurements

multipacting as function of filling pattern



550 ns spacing



~5.25 μs spacing

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remembering Francesco:

Francesco's has, off course, contributed to many more scientific studies

the presented examples only show a small set of projects where I could work together with him (and many more examples are given by other speakers)

➔ all examples shown in this presentation underline Francesco's ability to bring people together and to work as a team for a common goal

➔ he contributed much more to our community than with his scientific studies

➔ Francesco will not only be missed as a knowledgeable scientist but also as a colleague and friend